

THE

17

COAST SURVEY

OF THE

UNITED STATES.

---

EXTRACTED FROM THE AMERICAN JOURNAL OF SCIENCE, VOL. XLIX.

---

NEW HAVEN:

PRINTED BY B. L. HAMLEN.

---

1845.

# Coast Survey



Digitized by the Internet Archive  
in 2018 with funding from

This project is made possible by a grant from the Institute of Museum and Library Services as administered by the Pennsylvania Department of Education through the Office of Commonwealth Libraries

## THE COAST SURVEY.

---

THE interest which the readers of this Journal must have always felt in the condition and progress of the United States coast survey, has been very much (and naturally so) increased by the appointment of Dr. Bache to the office of superintendent. The work is now exclusively under American control, and though science, 'as broad and general as the casing air,' recognizes no invidious distinction of age or climate, yet reproaches which it is not worth while to remember, still less to repeat, have forced this consideration upon the notice of all those who feel a just pride in the scientific reputation of the country.

Among the readers of this Journal the present superintendent numbers many personal friends, and many others, who, governed by his reputation, gave the influence of their names to secure his nomination for his present responsible office, after Mr. Hassler's death. To these gentlemen, the successful prosecution of the coast survey has become a matter of more than ordinary interest. They may be said to have assumed a responsibility with regard to it. They will be glad then to learn something of its scientific details.

The fundamental principles of a geodetic survey, are of too elementary a character to be treated in this place. Neither will the reader look here for an abstract of the last report, showing the space occupied, and the amount of labor performed. Both of these topics have been recently handled with great clearness and elegance, in a popular form, by a writer in the "Biblical Repertory and Princeton Review." The object of the present article is to make known some of the new methods of observation and reduction which Dr. Bache has himself introduced into the survey, and certainly it cannot but be regarded as a favorable sign of the times, that the means are supplied for writing such a paper; that openness and freedom of communication are substitu-


ted for secrecy, and the habitual mistrust, to say nothing worse, which mystery always implies.

It is only necessary to remark before entering at once upon the subject, that a slight divisional arrangement has been adopted for convenience, and that having to speak of such changes only as are due to Dr. Bache, a frequent reference to his name is unavoidable.

In the determination of *latitudes* the superintendent has adopted a method in accordance with the established facts of observations, and with the extent of his means and authority. It is undoubtedly most desirable that the work should finally rest for authority in its astronomical determinations upon two permanent and well endowed observatories in distant parts of the country. Such was the project of Mr. Hassler, and it was owing perhaps to the hope that it might be realized, that up to the time of his death, no regular astronomical observations had been made at any of the stations of the primary triangulation, since leaving Weasel. During this interval, however, (it would be unjust to omit the mention of it,) some voluntary observations have been contributed by Mr. Edmund Blunt, one of the two principal assistants.

But the prospect of obtaining the efficient support of a well conducted observatory in the southern section of the Union is distant, notwithstanding the noble efforts directed to that object in Alabama. In the mean time it must be considered the part of prudence, as well as fidelity, to accomplish all that is possible, and the superintendent has undertaken this in such a manner that the results will form an interesting contribution to physical science, independently of their value in settling individual positions. Last summer, observations for the latitude were made at six stations of the survey, four at the north, and two at the south, and this season the same observations will be continued, not only at the stations of the new primary triangulation, but also to supply the deficiencies of the old work. The principle which demands these frequent determinations, is the necessity for reduction to a central point, arising from the irregularities of gravitation, occasioned by the variations in form and density of the materials composing the earth's crust. The theory, though

familiar to the student of physics, requires to be stated in this connection. If in consequence of the proximity of a mountain the plumb line be drawn from the position it would otherwise maintain, it is evident that the point of the heavens which corresponds to the zenith of a station, as determined by astronomical observations, would not be the same as if the mountain did not exist. The apparent direction of gravity being different, the apparent horizontal line is also changed. The length of the radius of curvature of the meridian undergoes a corresponding alteration, and the angle which measures the elevation of the pole, has its vertex, not at the centre of the earth, but at a point at a distance from the centre, depending upon the apparent line of direction of gravity.

The existence of such an attraction is a valuable part of knowledge, proved by accurate practical investigation. Observations were made in the year 1774, by Dr. Maskelyne, for ascertaining the attraction of the mountain Schehallien. The points to be compared were connected by measurement, and determined astronomically.  Two results differed  $11''\cdot7$ ! from each other, which great discrepancy is to be attributed to the sum of the deflections of the plumb line on the opposite sides of the mountain. *the*

Baron de Zach, also, in 1810 showed that the attraction of the Mimet mountains, near Marseilles, was appreciable. It appears to have produced an error of  $1''\cdot98$  in the latitude. M. Arago condemns the repeating circle used by Zach, and Mr. Airy observes that the stars were all on the same side of the zenith, a change therefore in the constant error of the instrument would produce an error in the result. Without attaching any importance to the minute accuracy of the determination, however, it sufficiently illustrates the principle treated. The same facts are attested by the observations of Boscovich and Beccaria in Italy.

It might be expected that the pendulum, a more delicate means of experiment, would also indicate by its vibrations the existence of these irregularities. Such is indeed the case. It is now well known that the attraction peculiar to the locality, does in frequent instances affect the mean force of gravity; and it is owing to the gravitating force, not only of the base on which the pendulum

stands, but also of the adjacent materials, that it is necessary to modify the rule, which would obtain, were the earth of an uniform density, viz. that the reductions from one level to another are strictly proportioned to the squares of their respective distances from the earth's centre.

Instances appear of defect and excess in the vibrations of the pendulum, of the former at Maranham and Trinidad, and of the latter at Spitzbergen and Ascension, where the experiments were conducted with such extreme precision as to prove conclusively that the irregularities are not to be charged to the experiments themselves, but to the natural phenomena which it is their purpose to investigate.

But to return to astronomical indications. Observations show that the attraction of masses comparatively small, is sensible. The discrepancies noted in comparing different parts of the same arc may be cited. At Arbury Hill there was found a difference of  $5''$ , not to be accounted for upon any supposition of the earth's figure. There is also an unexplained disturbance at Dodagoontah, on the great Indian arc, to nearly the same amount. In inferring the latitude of one place from the observed latitude of another not on the same meridian, through the medium of a geodetic measure, results are obtained differing from observation more than could happen in the use of the astronomical instruments, or of the geodetic measurements, without the most unreasonable neglect. Thus the latitude of Turin deduced from that of Milan differs from the observed latitude by  $8''\cdot9$ , that of Venice from the same origin  $9''\cdot5$ , and that of Rimini  $27''\cdot4$ . The same results appear upon the journals of the coast survey. The latitudes of New York and Boston do not agree together. Boston, Cape Henlopen, and New York differ from Philadelphia, and the various stations about the city of New York, when transferred to a central point, are all at variance with observation.

Finally, the great disagreement, it may be observed, between various geometers as to the ratio of eccentricity, is attributed by some writers, in a measure to erroneous latitudes, occasioned by deviations of the level.

These facts, and the theory which flows from them, prove the importance of the rule of observation adopted by the superin-

tendent. He not only arrives at the most correct determination of latitude compatible with the means allowed him, but is rendering valuable aid towards the thorough investigation of a very interesting question, a question intimately connected with his future discussions of the figure of the earth.

In connection with this subject, it may be mentioned that it is the design of Dr. Bache to employ observations of transits over the prime vertical for the determination of latitudes, as soon as the requisite instruments can be supplied. During the preceding winter the latitude of Cambridge observatory was determined in this manner, with such admirable coincidence in the results as to leave nothing to be desired. The observers were, Major Graham of the Topographical Engineers, Mr. Wm. C. Bond, the director of the observatory, and Mr. G. P. Bond, his son. The observations were reduced by Prof. Peirce, and will appear in the Transactions of the American Academy. They have also been communicated by Prof. Peirce to the office of the coast survey.

*Astronomical azimuths* require also frequent determinations in order to ensure accuracy, and to save the ungrateful labor of retrospective calculation. With regard to this important element in geodesy it is theoretically true, that when one azimuth has been defined, others can be deduced from it by simple calculation in the progress from station to station. But repeated measures for verification are indispensable to avoid error, and to escape the trouble of reoccupying old stations. During the preceding season the azimuthal bearing was ascertained, independently, for six of the primary stations, four at the north and two at the south.

Of the two heavenly bodies most commonly used in this operation, Mr. Hassler preferred the sun, but Dr. Bache has employed for the first time on the work, the elongations of Polaris, in both its eastern and western digressions. His objection to the sun is the exposure of the instrument, which cannot fail to be affected by the heat of this luminary.

A distinguished astronomer, it may be remarked, directed the English surveyors never to use the sun for any geodetic determination. The prominent advantage in using Polaris, is the opportunity it affords for a very careful and deliberate observation. At the time of elongation, when the change of altitude is most

rapid, the movement in azimuth is nothing ; there is ample time therefore to repeat the measurement until satisfied with its exactness. The observations are continued for several successive days. The necessity, as it is generally considered, of using distant night signals for this mode of determining azimuths, is avoided. The superintendent has adopted the suggestion of the Astronomer Royal at Greenwich, who proposed referring the points of greatest elongation of circumpolar stars, to marks in the horizon, by perpendicular lines demitted by means of an altitude and azimuth circle. Elongation signals are established about two miles distant, consisting of a delicate wand by day, and a lamp by night, the latter of which is seen through a small hole perforated in a board set up for the purpose.

This method is peculiarly applicable to a large theodolite with a micrometer eye-piece,—first the position of the star is observed and then the signal with the micrometer, and so on alternately for ten minutes before, and ten after elongation. Many observations are accumulated in one day, care being taken to ensure the steadiness of the instrument and the correct leveling of the axis. Measures were made by the reflected, as well as the direct image of the star, but this precaution was found to be superfluous. The elongation signals are observed in turn with all the other signals, and the probable error of the results is found to be less than the best on record in the French survey when the repeating circle was employed. The French used Polaris near elongation, but not both elongations. Distant night signals have been attempted with general success, and for this purpose a lens was borrowed from Mr. Lewis. Where these were set up, the arc of distance from Polaris to the signal, which is the measure of the diedral angle formed by the two vertical planes of the signal and star, could be taken directly, and this, it is believed, was the method most in favor in the recent French triangulation.

Concerning the observation of *terrestrial angles and the use of the large theodolite*, Mr. Hassler has very justly said, that, “Absolute mathematical accuracy exists only in the mind of man. All practical applications are mere approximations, more or less successful. And when all has been done that science and art can unite in practice, the supposition of defects in the instrument

will always be prudent. It becomes, therefore, the duty of an observer to combine and invent, upon theoretical principles, methods of systematic observations, by which the influence of any error of his instruments may be neutralized, either by direct means, or more generally, and much more easily, by compensation. The methods thus decided upon will determine the number, as well as the form and combination, of the observations which are required to give the greatest probability in the results; and these methods must be the constant rule for all observations."

That portion of geomorphy which comprises the measurement of terrestrial angles of the first order, demands the nicest exactitude, because it embraces the consideration of the earth's figure, and because the celestial observations of a geodetic survey are directly connected with it. That observations should be numerous, as one mode of compensation, is evident.

Another question arises as to the best circumstances in observing, and the number necessary to secure a very small probable error. This question the superintendent has now resolved, by an application of the method of least squares for the first time on the survey. Its general and successful use by Prof. Lloyd, in the magnetic survey of Great Britain, may be seen in the eighth Report of the British Association. There is reason to think that the method adopted by some engineers of selecting for observation those times only which appear the most favorable in all their minutest circumstances, does not lead to the best results. Swanderger in Lapland may be here particularly referred to, whose observations, very few in proportion to the time occupied, do not appear to have commanded the highest confidence. Now the mode introduced by Dr. Bache has been to determine, by repeated trials, and by a rigid application of the method of least squares, what is the number of observations which, taken under circumstances such as are ordinarily favorable, will reduce the probable error within the limits of deviation of the instrument, and of the observer. That number, thus established, becomes the rule of conduct. The application of this method has increased not only the economy, (a very important consideration, for economy is progress,) but the rapidity of the work in a striking manner, as

may be seen from a comparison of the field work of last year with that of any previous year; and, what is most to be regarded, it secures a greater accuracy in the compensation of errors. Of six triangles, the greatest difference from  $180^\circ$ , after allowing for the spherical excess, was  $0''\cdot6$  of a second of space, that is  $0''\cdot2$  to an angle, and from this the difference descended to nothing.

The nicety of this result rivals both the English and French surveys. It is not necessary to carry comparisons (which may appear invidious) any farther at present; but they need not be shunned, whatever the source or standard by which they are challenged. It is only necessary to add that the calculations were not made by Dr. Bache himself.

This subject leads to the mention of the formulæ used upon the survey for the calculation of L. M. Z. which depend upon the figure of the earth. The value of  $e^2$ , the expression by which the ellipticity enters into these equations, has been variously decided by the most distinguished geometers, and has resulted differently from the comparison of different meridional measurements; from experiments with the pendulum by different observers, and from calculations of it from the moon's motion by La Place and Buckhardt. The history of these facts will be familiar to the reader. Among the comparatively modern determinations, the linear measure of Mason and Dixon in 1764 has given a result in one extreme, and the magnificent triangulation of Méchain et Delambre in the other. This is precisely one of those questions in which the purely practical depends upon the purely theoretical, and that of the highest order. The direction hitherto taken by the main triangulation of the coast survey does not enable it to supply the measurement of an arc of meridian, that is, an element for deducing the figure of the earth satisfactorily. But it is now approaching this point. The triangulation from Nantucket, (which will be one of the points of the first order during the present season,) to Portland, will qualify the survey to take its place in this respect also amongst the permanent scientific works of the world.

From the head to the mouth of the Chesapeake will be formed another series, favorably situated for this purpose, and here the line of Mason and Dixon will be included and its accuracy tested.

The tables for the reduction of triangles, and for projection, were first calculated by Mr. Hassler in 1818, but in 1834 he found it necessary to repeat all the calculations,—the knowledge of the dimensions and figure of the earth having been much improved and more strictly defined. Since then, however, has appeared the determination of Bessel, founded upon a comparison of all the authentic measures, to each of which is assigned its just weight as determined by the theory of probabilities, or the method of least squares. This is the result accepted by the scientific world, and which it is *now* imperative to employ. Not only are new tables to be calculated for future use, but all the old triangles are to be recomputed to the original base. The accumulation of small errors renders this course obligatory, and indeed indispensable. But the values in the new tables will be affected not so much by the change of ellipticity, as by a proper return to the *legal* ratio of the metre to the toise. The toise was the standard of linear measure in France, employed in the measurement of the French arc between Dunkirk and Barcelona, and virtually also in its continuation by MM. Biot and Arago, by which the parallels of Paris and Formentera were connected. Virtually it is said, because the legal ratio of the metre was preserved. The definition of the metre as the millionth part of the quadrant of the meridian, having been shown by the laborious computations of Colonel Puissant to be imaginary, it only remains to adopt and preserve the value given it by the law of 1799, and subsequently confirmed by the law of 1837.

It might be argued, if argument were applicable to the case, that the attempt to assign to the metre a theoretic value would defeat itself,—for neither geodesic operations, nor the present methods of calculation, could settle its value with such certainty but that future geometers might find occasion to modify numbers which now appear to be the most established. It may be said, further, that when the metre was adopted by the commission consisting of Borda, Lagrange, La Place, &c., it was done with a limitation subsequently confirmed; and this limitation, being a very close approximation to the truth, may be regarded as definitive. Whatever may be the future progress of science, it can never be convenient to alter it; but it is only requisite to have a

distinct idea of what it represents. Upon this subject Mr. Hassler assumed a different, and as it has been pronounced by very high authority, a novel idea. When the standard metres were distributed by the committee of weights and measures, Mr. Tralles, the deputy from Switzerland, obtained an extra one, perfectly authenticated, which he presented to Mr. Hassler. The latter, having in his possession five brass and three iron metres, and several standard toises, including those of Canivet and Lenoir, instituted a series of comparisons with the comparateur of Troughton, which can never fail to command the most sincere admiration for the philosophic accuracy and elegance of their execution, but by means of which he arrived at a ratio independent and exclusive. His purpose was to establish an authentic standard with bars of recognized authority. Had the subject required further research, no one could hesitate to admit his results, as every one must admire the zeal, learning, and fidelity he displayed. But the legal ratio is in fact the only one admissible. This is an evident truth. When the metre ceased to be considered the ten-millionth part of the quadrant of the meridian, it became equally with the toise a mere iron bar, having no other value than that assigned it by law; and that value was a permanent one, which no individual experiments could be permitted to change.

On this point there can be no higher authority than that of M. Bessel, which it may be well to quote. "Mr. Hassler deduced from several comparisons the value of the metre in parts of the toise. But this I consider as not allowable, for the ratio between the two is determined by law, by which the metre has received its true definition. If certain copies of these metres do not agree together, *it shows that the law is not exactly fulfilled by them*; and as it is much more difficult to transfer to another metallic bar 443·296 lines of the toise than the whole length of the toise, the value of the metre is a circuitous and unprofitable way, as long as the toise is as easily obtained as it was at the time of the construction of the metre."

Mr. Hassler's ratio differed from the legal ratio (443·296) by  $-0\cdot015$  lines of the toise, an amount quite serious when multiplied by frequent repetitions.

At the primary stations last year Dr. Bache made use for the first time of vertical angles for determining differences of heights. For this the triangulation at the north offers a fine field ; but the features of the coast at the south will preclude its frequent application there. This method will be continued. The effect of refraction near the surface may be investigated by a series of observations, and these angles can be measured at a time of day when it would be impracticable to observe the horizontal angles.

A new system of *magnetic observations* has been introduced into the coast survey. The declination of the magnetic needle, which is of indispensable practical utility, is to be carefully ascertained at every important station of the work. It is needless to say, however much the subject may have been neglected hitherto, that without it any map or chart would disgrace the office from which it issued. To this the superintendent has added other results without increase of expense. There is no branch of physical science which, at present, engages more active attention than magnetism. The magnetic surveys conducted and observations established by the government of Great Britain at home, and all over the world, are worthy of the munificent support that nation has always given to science, and the diffusion of sound knowledge. It is a matter of humble pride that something has been done also in this country, at the magnetic observatory of Cambridge under the direction of Professor Lovering and Mr. Bond, and still more at the observatory of Girard College under the direction of Dr. Bache. The publication of the latter observations, with the curves of diurnal and monthly variation, by the government of the United States, enables this country to add a respectable mite to the general contribution. The new instruments invented by Dr. Lloyd and M. Weber, are now used upon the survey.

The portable declinometer of M. Weber, (perfected by Lieut. Riddell, and manipulated according to his instructions,) measures inclination, and also, by a subsidiary apparatus, the horizontal force, according to the method of Gauss. The bar being vibrated gives *magnetic moment. of bar  $\times$  hor. mag. intensity*. And the same bar used to deflect another suspended at different distances, gives a series representing *mag. mom. of deflecting*

*bar÷hor. mag. intensity*, and hence the true horizontal force is derived. Excellent results have been obtained by Fox's dip circle, with the use of the deflecting magnet. The axis in jeweled holes has a projecting stem, which is rubbed with an ivory disk to ensure perfect freedom of suspension. To this happy plan of creating a slight motion of the axis, a Frenchman has applied the significant term of *shuddering*. By means of these instruments the *declination, inclination, and intensity*, (both horizontal and vertical,) are determined, and thus whilst the useful and necessary are sought, valuable additions are made to the general magnetic researches.

Local attraction, and the consequent imperfection of courses on board of a vessel, will receive the attention their importance demands. Experiments made last summer on board of the brig *Washington*, belonging to the coast survey, showed a considerable local variation, and also suggested the means of its correction. This was the first occasion on which this subject had been investigated on the work. It is the design of the superintendent to apply the beautiful and simple mode of correction proposed by Mr. Airy. It is impossible to allude to his experiments on board the iron steamer *Rainbow*, in the basin of the Deptford dock-yard, and the calculations based upon them, without noticing this as a remarkable case where a theory purely scientific leads to the most useful practical results. Mr. Airy's combination of the theory of M. Poisson with regard to the equal attraction of solids and hollow spheres with his own hypothesis of the magnetic direction and intensity of the particles composing an iron steam-vessel, established the safe use of compasses where it was before supposed to be very insecure if not impracticable.

The subject of *tides* is now treated in a manner altogether new upon the survey. It seems to have been imagined, that the only purpose of tidal observations was to correct local soundings, and to ascertain the time of high water on the very days of full and change, or the vulgar establishment, and for this the solar interval alone was sought.

Even in this humble attempt, time appears to have been kept very loosely. Observers have been sometimes employed who had little idea of the importance of their office. The reforma-

tion introduced is thorough. The times of high and low water, and the period of slack water, are found by watching the register unceasingly from half an hour before to half an hour after the change, and noting the time and height at very short intervals. It was first proposed to lay down these times and variations in height upon a large scale, and drawing, at the extremity of the curve traced through them with a free hand, a tangent parallel to the line of abscissas, to take the ordinate perpendicular to this tangent as the nearest approximation to the time of high water. But upon trial, this was not found to differ perceptibly from the numerical means of the times. The latter is therefore used as by far the most convenient. In the reductions, Dr. Bache has adopted the methods rendered familiar by the papers of Prof. Whewell and Mr. Lubbock. *Corrected establishments* are derived from the mean of the lunital intervals. As soon as observations accumulate sufficiently, at any prominent point, the curves of semimenstrual and diurnal inequality will be projected, the observations will be calculated for the effect of winds, and barometric pressure, and the variations in the times and heights of high water due to changes in the moon's parallax, declination, and motion in right ascension, will be investigated by a comparison between computation and observation.

The practical benefits of this system in determining the tide-factors, and in tracing the times, courses, and conflicts of the tides in the harbors and inland seas of the United States, cannot be too strongly enforced. And perhaps even the further suggestion may be humbly ventured, notwithstanding the unpromising results of Prof. Whewell's endeavors, that predictions to be relied on, which would be infinitely serviceable in the preservation of life and property in some of our bays and rivers, can be based upon future accumulated observations. If this hope should ultimately prove fruitless, no one will deny that so noble an object is worthy an effort.

Dr. Bache has also begun to set up *self-registering tide-gauges*—one has been in operation during the last six months, at Governor's Island, another is now in process of construction at the office in Washington. The former of these was invented, in its details, by Mr. Wightman, philosophical instrument-maker

in Boston. The axis of a hollow copper cylinder, upon which the paper is secured, is connected with the pinion of a clock, and revolves correspondingly to the hands. The rim of a cylinder is divided in parts of an hour, and these divisions are transferred to the paper by a rule ingeniously contrived. A brass chain, (guided by the requisite pulleys,) with the float in a well at one end, and a weight at the other, passes round a wheel in the prolonged axis of which, directly over the cylinder, is fixed the pencil. The well is guarded from the external motion of the water, and the motion of the float is communicated to the pencil by means of a screw.

The second tide-gauge is the invention of Mr. Saxton, late the balance maker of the U. S. Mint, and there particularly distinguished for his improvement of the parallel ruling-machine, by which it was made perfectly useful, after being thrown aside in despair by the original inventor. Mr. Saxton is now the constructor at the office of weights and measures, at Washington. His tide-gauge has two cylinders. One is carried by the clock, and receives the paper after the tidal curve is traced. The other carries the blank paper, and is assisted in its revolutions by a weight, thus easing the labor of the clock. The pencil acts between the two, and the intervals of time are noted by a marker connected with a striking apparatus.

*Several* In the former tide-gauge, the curves are repeated on the same paper—in Mr. Saxton's a continuous curve is traced from day to day. Both machines have ~~retinal~~ scales which can be adapted to the variable rise and fall at different places.

The leading principle in these gauges is the same as in those of Lieut. Palmer, published in 1833, and of Mr. Blunt, in 1838.

The dependence of practice upon theory is well established. The contributions of science to meet the daily wants of life, constitute her highest claims to respect and encouragement. In addition, however, to the useful results to be obtained from the researches into the nature of tides upon the shores of the United States, the friends of science, in this country, will be gratified to see that the superintendent has taken the first step towards rescuing the nation from the reproach of having hitherto entirely neglected this important branch of practical astronomy.

In conclusion it may be mentioned, that with twelve connected establishments determined at the office last winter, an attempt was made to deduce the place and direction of the co-tidal line, of XII hours upon this coast. The formula used by the superintendent was regarded as a means of approximation only, the co-efficients being subject to future modification. m

The direction and velocity of *tidal currents* are now subjected to a rigorous investigation. They are determined for the normal condition of the tides, and for the effect of occasional deranging causes, such as winds, &c. The work is laid down upon circular and rectangular diagrams, both of them showing the courses and rates of motion. When accidental influences are the subject of examination, the mean is taken of several days' observations made under suitable circumstances, the temperature of the water being always recorded in the note-book. For this duty a new hydrographical party is added to the survey.

Connected with the study of currents is the *exploration of the Gulf Stream*, a work of vast labor and much time, for which the preparation is already begun. The magnitude of this task cannot be estimated. Its practical and philosophical bearings were ably treated by the committee of the scientific convention at Washington, of which Lieut. Maury was chairman. They need not, therefore, be dwelt upon here; neither will any thing be said, at present, of the course of investigation to be pursued, farther than this, that deep-sea temperatures, and the shelving of the coast parallel to the land and water within the borders of the Gulf Stream, will not be overlooked.

As the operations of the coast survey depend upon the weather, the necessity for full and systematic *meteorological journals* is apparent.

Printed forms have been distributed by the superintendent, in which the weather, the state and temperature of the atmosphere, and the employments of the day are recorded by each assistant. At the new primary stations, the barometer and dew-point are noted. Besides the strict personal accountability, incidental benefits will spring from this mode of journalizing. Among them may be enumerated the means of estimating the probable progress of the work at the north and at the south, at different seasons of the

year, the assistance they will afford in tracing the courses and studying the nature of storms, and the exceedingly valuable help they will supply for laying down, at some future time, a map of temperatures and climates throughout the coast region of the United States.

It would occupy too much space to mention the number of new printed forms now in use upon the work,—but their value cannot be questioned. Literal instructions may be differently construed by different persons, but the order to fill up a printed form according to the headings, leaves no room for misconstruction or latitude of interpretation. This, however, may be carried so far as to trammel individual effort, and control individual intelligence—but the evil is too apparent to have escaped notice.

The most serious and painful embarrassment is incurred by the present head of the survey, from the deficiency of good *instruments*. Just in proportion as the observer is proud and happy in the manipulation of good instruments, so is he dispirited and anxious with bad ones, which require endless repairs, tedious processes for the rectification of errors, and threaten, after all, to disgrace him by imperfect results. It seems worse than ridiculous to expect that a work of such delicacy and magnitude as the geodetic survey of the coast, can be conducted without an ample supply of the best instruments, yet Dr. Bache has been compelled to borrow a transit instrument from the State of Massachusetts, an altitude and azimuth circle from Columbia College, (now returned,) a repeating circle from West Point, and to purchase from Mr. Blunt, a Gambey theodolite, imported for his own use, which fully justified the high character of the maker. For this department there should be a separate appropriation, and it is to be hoped, that next winter the earnest appeals of the superintendent, supported by some intelligent members of Congress, who can appreciate the vital necessity of the case, will be heard with favor. In the mean time he is doing all in his power to remedy the gross deficiencies. A transit telescope has been ordered from Simms, and from Gambey a theodolite of the largest class, suited to astronomical observations and to the measurement of horizontal angles. Encouragement is given to our mechanics at home, from whom the smaller instruments are ordered, as they

are wanted. A theodolite, by Patten, has lately been divided at the office with the dividing engine belonging to the coast survey. A vast deal of work, such as repairs, new mountings, &c., is done upon instruments in the workshops of the office at Washington. The vertical circle of the three feet theodolite has been ~~unseparately mounted~~ *separately mounted* during the past winter, and a new horizontal circle graduated for the purpose. The fitting of the microscopes for the large theodolite has also been altered, so as to render the adjustments more easy and permanent. To these repairs may be added the making of drawing instruments, and engravers' tools. This work, done under the eye of those who are to use the instruments, is attended with a saving of time and expense.

The dividing engine of Mr. Troughton, belonging to the coast survey, which has been referred to, has been made automatic by the mechanical genius of Mr. Saxton. This instrument had been but little used. Two days were required to divide a circle, and the change of circumstances in the interval, the inconvenient position of the workman, and the effect of the heat of his body, created doubts of its accuracy after trials by experienced workmen. Now that it is self-acting, it performs, in one hour and ten minutes, the work which before consumed two days. The turning of a crank gives the necessary slow motion to the circle, raises the cutter, pushes it forward, and draws it back in such a manner, that it marks lines of four different lengths—10', 30', 1°, and 10°, and finally it throws itself out of gear when the division of the whole circle is completed. The centering was found defective, but now this and all other errors are effectually removed, except some small irregularities in the teeth of the main wheel, which will, in turn, be corrected. This engine admits a circle four feet in diameter, and will answer for the whole country.

There is one respect in which the superintendent has adopted a course entirely new, which must meet with the hearty approbation of the friends of learning throughout the country. In various parts of the United States, but principally attached to learned institutions, are found gentlemen who are led by taste, as well as professional pursuits, to make observations of value to the coast survey, especially in latitudes and longitudes. The superintend-

ent purchases their results, of the highest value, because made by experienced observers, and with better instruments than the coast survey could furnish. Professors may profitably employ their summer vacations in similar labors. It will be recollected that Dr. Bache himself, while filling a chair in the University of Pennsylvania, made the magnetic survey of ~~this entire state~~ during the term intervals of two years. Prof. Renwick, of Columbia College, was engaged last year in making experiments in Long Island Sound, with the new magnetic instruments before spoken of, for the coast survey. Mr. Bond, of Cambridge, communicates the meridian differences, by chronometers, between Boston and the British observatories. These have become numerous since the establishment of the line of steamers, and the commencement of Commodore Owen's survey of the Bay of Fundy. And Mr. Walker, of Philadelphia, has in charge the reduction of all the observations on record at the office, bearing upon the longitudes of coast-survey positions. Every one will admit that this duty, as extensive as it is laborious, could not be placed in more responsible keeping.

In the same spirit, observations at fixed observatories, occultations, eclipses, and moon culminations, and also for latitude, are procured and reduced to central points of the survey. It has already been mentioned, that the results of the transits over the prime vertical at Cambridge, have been communicated by Prof. Peirce. This system is the more necessary, because the coast survey can neither supply instruments nor observers for important occasions. The solar eclipse and transit of Mercury of last May, for instance, were observed by Dr. Bache, at Great Meadow station, near Taunton, and by two assistants, one at Portland, and one at a station near Baltimore ; and further than this the means of the work did not extend. But the records of the same phenomena are to be communicated from Cambridge, Brown University, and Philadelphia. Major Graham also has kindly placed his observations, made at Governor's Island, at the disposal of the superintendent. Collaterally with the same work in the office, scientific men, in private life, are engaged to report all the important calculations of the survey. The security against error afforded by employing persons, to compute, who have had no

connection with the duties of the field or the observatory, is well understood.

The policy of the system now described, which gives support and encouragement to scientific men at home, which procures for the coast survey the use of good private instruments, and the assistance of accomplished observers and computers, which enlarges the sphere of labor in a way not less notable for its economy, than its practical benefits, cannot but receive universal sanction. It is intended to multiply, hereafter, observations at the principal stations of the work, of occultations and moon-culminating stars. The predictions of the former will be put in the hands of a distinguished mathematical professor.

Much remains to be completed in the area occupied before Mr. Hassler's death. To bring up this old work is an unthankful office; but this is to be done whilst the constant progress of the new is not interrupted. An assistant of Dr. Bache's party is now employed in the Chesapeake. One of the two principal assistants is reconstructing the old triangulation in Delaware Bay. The important changes at Sandy Hook, developed by the renewed survey of last year, demand further examination. The number of similar cases may be expected to increase every year, especially as the survey advances to the southward. These facts are equally interesting to the geologist as to the navigator. There are few cases of change recorded in Mr. Lyell's treatise more striking than that at Sandy Hook. The investigation into their causes, belongs to the geologist, yet he must receive the basis of facts from the surveyor, and it will not be forgotten, that among these facts, are to be noted the local appearances, the direction in which the sea strikes the coast, the comparisons of soil as far as they may indicate the local connections, together with such others as will serve to guide the philosophical inquirer. It would lead to but a partial estimate of the value of the coast survey to omit these, as well as other considerations, upon which there is not time to dwell.

How well the coast survey has fulfilled the principal object of its institution, that is, the improvement of the navigation of our own shores, has been already amply illustrated. The channel newly determined at the entrance of New York bay, if known,

would have permitted the entrance of D'Estaing's fleet, and it appears, from a comparison of the curves of soundings, that it must have existed at that time.

In Delaware Bay, there has been determined a new and straight ship channel, three smaller channels over the ridges of Cape May, and a dangerous shoal lying very near the main ship-channel. At the entrance of Delaware Bay, near Capes May and Henlopen, three shoals have been accurately defined ; and a rock has been found at the entrance of New Bedford harbor, between the light-houses. But while navigation and its wants are the prominent object, information is incidentally furnished to facilitate works of fortification and internal improvement. Such was the case with regard to the fortifications projected near Sandy Hook, in the construction of the New York and New Haven railroad, and of the light-house on Tucker's Island, and in the improvements on League Island in the Delaware, and the project for carrying the Croton water to Brooklyn across East River.

Another point of real importance, which will receive the care and cordial co-operation of the superintendent, is the permanent position and systematic classification of buoys. This cannot be so well done until after the chart of the particular place is issued from the office. At present the buoys in our harbors are not well arranged, and hardly occupy the same place in two successive years. Taking the harbor of New York for an example ; there are a certain number of black and white buoys precisely alike. If the mariner falls in with one of these buoys in a fog he has no means of knowing whether it marks the 'outer-middle,' or the 'west-bank,'—whether it is the buoy of the North channel, or of the S. W. Spit. That is, he must know his position by the bearings of familiar objects on the land, before the buoy can be a guide to him. The reader will at once perceive that if the British rule were adopted, of putting the buoys of one color on one side of the channel, and those of another on the other side, and numbering them in order from out, inwards, then the mariner in the night, or a fog, falling in with one of them, would know the precise spot he was in, and the course to be steered to the next buoy. Further details could be added concerning their moorings, as for example, the propriety of using the screw pile,

introduced into this country by Capt. Wm. H. Smith of the Topographical Engineers, but the preceding hasty remarks show the importance of the subject, and its present state of neglect. *Smith*

Since the coast survey has been under its present head, five sheets of charts have been issued ; four of them are sheets of the large chart of New York bay, and were two-thirds done under Mr. Hassler. Two more are wanting to complete this set. They will contain the south side of Long Island, and the east entrance of the Sound, and may appear before this paper is published. The small chart of New York bay and harbor has been for sale for some time in the principal cities, and begins already to be in demand. The charts of Delaware Bay, of the coast of New York, and of Long Island Sound, are in the engraver's hands and advancing rapidly. In order to expedite the publication, and employ the skill and talent of other engravers, maps of the smaller harbors will be executed out of the office. The maps of Fisher's Island of the old work, of New Bedford and Annapolis, with the Severn of last year's work, are in progress. This is a part of the system of getting out results as soon as possible. The last mentioned will be engraved in a less elegant style of finish, being subject to future improvement, especially in their astronomical determinations. *Sound*

But this subject, however interesting, must be brought to a close. It was said at the beginning of this article, that the chief aim of it was to convey some idea of the methods and principles of observation and reduction introduced into the work by Dr. Bache himself, and to show that this noble undertaking has lost no ground during the past eighteen months of its existence. Even more than this could be justly maintained, were it not above all things, desirable to avoid unseasonable and unprofitable comparisons.

As the duties of the survey are numerous, various, and comprehensive, so the labor of arranging them, of adjusting each to the other, and making all harmonize together, of regulating their details and embracing their extent, of giving instructions to the head of every party whether in the field, or the observatory, or on the water, and receiving in return his reports and communications, is onerous and engrossing in the extreme. This is attended

to by the ~~present~~ superintendent personally, while all the angles measured, astronomical, magnetic, and other observations taken, and calculations made at the stations of the first order, are executed by himself, or under his immediate control.

There is one point of the highest import to the prosperity of the work, which must not be passed over. The coast survey, heretofore endangered by the absence of a controlling public opinion, now enjoys its efficient support, both in Congress and in the country generally. It enjoys, moreover, internal peace and harmony, a condition essential to the prosecution of scientific labors, and honorable to all.

It only remains to add, that the matters here treated being considered familiar to the general readers of this Journal, it has not been thought necessary to consume space by strict references to the authorities cited.